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Forest Pest Makes Home in Ontario

Landowners may find themselves battling gypsy moth populations in spring and summer because this introduced forest insect now claims many parts of southern and central Ontario as its "home".

Not all forest pests come into Canada by accident; some of them have help. The gypsy moth was purposely brought from Europe to the United States in1869 by a Frenchman named Leopold Trouvelot. A naturalist and entrepreneur, Trouvelot wanted to start a North American silk industry by crossing the gypsy moth, a native insect in France, with North American silkworms. His experiments took place in Medford, a small community near Boston, Massachusetts. The idea failed and Trouvelot returned to France but not before some of the insects escaped from his laboratory. The surrounding forest contained plenty of food and few natural enemies; within 20 years, gypsy moth had become a serious local pest.

Since the turn of the century, gypsy moth caterpillars have stripped oak and other broad-leaf forests bare throughout the northeastern United States. Strict quarantines and eradication attempts failed to prevent the slow spread. Gypsy moths first moved into Ontario near Kingston over 20 years ago. By 1985, the insect had become a serious problem in southeastern Ontario and has continued to expand its range in the province .

Forests and woodlots are valuable for their natural beauty, for wildlife habitat, for the forest industry and for recreation.

Any threat to our forests affects us all. Residents, cottagers, tourists, naturalists, hunters, anglers, farmers and those who depend on the forest industry for their livelihood, have a stake in protecting and maintaining forest health.

The purpose of this booklet is to inform people about gypsy moth and to suggest ways that individuals or groups of property owners can protect the health of their trees.

The gypsy moth is in the insect order *Lepidoptera*, which contains moths and butterflies, known for their beauty and, in some instances, for their destructiveness. Lepidopterans are characterized by having a complete metamorphosis, with larvae (caterpillars) transforming into pupae, then metamorphosing into adult butterflies or moths.

Scraping and destroying gypsy moth egg masses is a useful manual control method--for more details, see page 8.

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Working Towards Integrated Pest Management

The hope for the future regarding gypsy moth in Ontario is the practice of Integrated Pest Management or IPM.

One definition of IPM is:

"The use of appropriate techniques in an integrated fashion to reduce and maintain a pest population at an acceptable level with minimum social, economic and environmental impacts."

IPM is a decision-making system that considers the use of many treatments ranging from encouraging insect predators to the judicious use of insecticides. An IPM program can produce results that are environmentally safe and effective in controlling impacts of high gypsy moth populations. Careful tracking and evaluation of the gypsy moth is also necessary to make this system work. Before IPM can be effective, government agencies, scientists and the public must work cooperatively. The more you learn about the gypsy moth, the better your chances are to help in local efforts to promote an Integrated Pest Management System for gypsy moth.

There are six basic categories of control in an IPM system:

1) biological;
2) cultural;
3) manual;
4) mechanical;
5) chemical; and
6) regulatory.

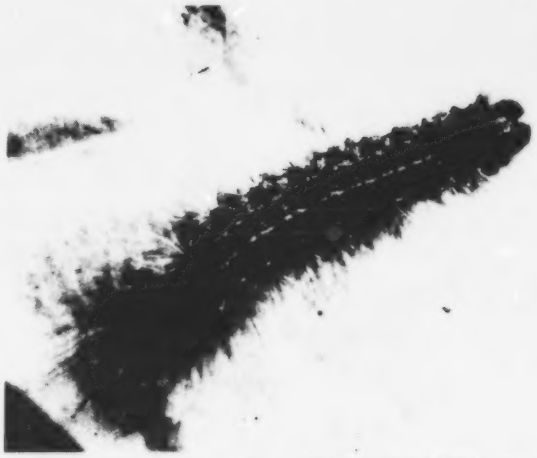
Biological controls include placing or attracting natural enemies such as parasites, predators, and pathogens (bacteria, fungi and viruses) into a gypsy moth infested area. Encouraging birds that are gypsy moth predators to your yard is an example of a **biological** control method; one that has the additional benefit of allowing your family to enjoy and learn about birds.

Planting tree species not favoured by gypsy moth is a **cultural** tactic for controlling this pest on your property. One of the best defences against gypsy moth is to keep your trees healthy.

Manual controls include hand-picking egg masses and collecting larvae in burlap traps.

Mechanical controls involve trapping males so they cannot mate, or otherwise changing the insect's access to food, reproduction areas, or protection from natural enemies.

The use of **chemical** pesticides to help control pest populations can be a component of an IPM program. The decision to use them, however, must be balanced with their potential effects on beneficial insects and other non-target organisms. The Ministry of Natural Resources relies on biological insecticides for aerial application in its pest management programs.



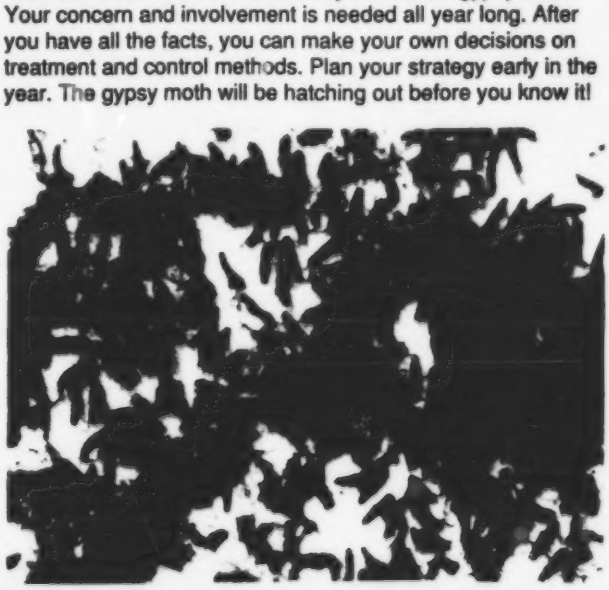
A mature gypsy moth larva on oak. (Copyright 1990 by Nathan Bacon).

Quarantines are **regulatory** measures used to prevent a pest from entering new areas. Checking vehicles and outdoor items for egg masses or other life stages of gypsy moth before moving them is an example of a quarantine used to prevent the introduction of gypsy moth into new areas.

There are ways that you can help combat the gypsy moth in your area by using one or more of these control methods. See page 8 for more details on how you can get involved!

Share Your Discoveries

Help your neighbours and friends understand this forest pest, as well as the actions taken by MNR, municipalities and local groups. Your help is needed in this way to make current control methods better and to find new ways to control gypsy moth. Your concern and involvement is needed all year long. After you have all the facts, you can make your own decisions on treatment and control methods. Plan your strategy early in the year. The gypsy moth will be hatching out before you know it!



Tiny gypsy moth larvae emerge from egg masses in early spring.

Do You Have a Gypsy Moth Problem?

To determine if gypsy moth is present in your area, you can conduct a survey for gypsy moth egg masses on your property. This can be done any time from August to April, though egg masses are easiest to spot when leaves are off trees and shrubs and there is no snow on the ground. Examine tree trunks and undersides of branches for egg masses. The eggs may also be on rocks, sticks on the ground, underneath and around buildings or on almost any outdoor article. Keep a rough count of the number of egg masses you see.

The size of the egg masses indicates the status of an infestation. When populations are declining, the masses are small (about the size of a dime) and contain 75 to 100 eggs. In stable or growing populations, each mass can contain up to 1,000 eggs and can be as large as 4 cm long and 2 cm wide (1-1/2" by 3/4").

The "rule of thumb" below can be used as a guideline to predict what impact the insect will have on foliage if all of the egg masses hatch and the caterpillars all survive. At forty per cent defoliation, the loss of leaves starts to become noticeable. This is considered to be a moderate amount of leaf loss.

A Minimum of : **1250 Egg Masses per hectare** **or** **500 Egg Masses per acre**	**will cause 40 % loss of leaves**

A gypsy moth caterpillar killed by a naturally-occuring virus--see page 9 for details. (Photo courtesy of Forestry Canada).

Will the Gypsy Moth Come to Your Area?

Gypsy moths move into new areas either naturally or by hitching a ride on equipment and materials.

Natural spread can occur on the ground or by wind transport. Natural spread occurs most rapidly where there is a suitable food source. Areas with red and white oak, white birch and poplar are preferred by the gypsy moth. The insect usually thrives in forests containing these trees.

Artificial spread of gypsy moths to new areas will occur regardless of the type of forest growing there. However, the gypsy moth will only thrive in areas where there is a suitable food source.

Where do Gypsy Moths Like to Live?

The composition of a forest is the major factor in determining if the gypsy moth will become established in a new area. Knowing the different species (kinds) of trees on your property will help you determine the probable impact of the gypsy moth.

Susceptibility of trees is a measure of the likelihood that the trees will be defoliated by gypsy moth caterpillars. A forest composed of mostly oak, birch or poplar is very susceptible to the gypsy moth. Areas with thin soils or exposed bedrock, and a combination of oak and young white pine are particularly susceptible to defoliation by gypsy moth.

Areas where sugar maple, ash, spruce or pine predominate are much less susceptible to gypsy moth defoliation.

The gypsy moth is primarily a pest of oak, poplar and birch trees. When gypsy moth populations are high and the preferred food source is exhausted, gypsy moth caterpillars have been known to feed on the leaves of over 500 plants including agricultural crops and masses.

Refer to the chart on page10 for a more complete list of tree species preferred by the gypsy moth.

The Four-Stage Life Cycle of the Gypsy Moth

Eggs laid in August become leaf-eating caterpillars the following May

The gypsy moth begins life as an egg laid in late July or early August. The exact timing depends on the weather, food sources, and other factors such as disease. Each female lays a fuzzy, buff-coloured egg mass that resembles a small piece of chamois. Although the female prefers sheltered places such as bark crevices, she may lay her eggs on buildings, lawn furniture, automobiles--just about anywhere.

Inside each egg, an embryo develops quickly. The fully formed larva spends the winter inside the egg in a state of dormancy. The following spring, in late April or early May, when temperatures are warm enough, the larva chews through the covering of the egg mass and emerges.

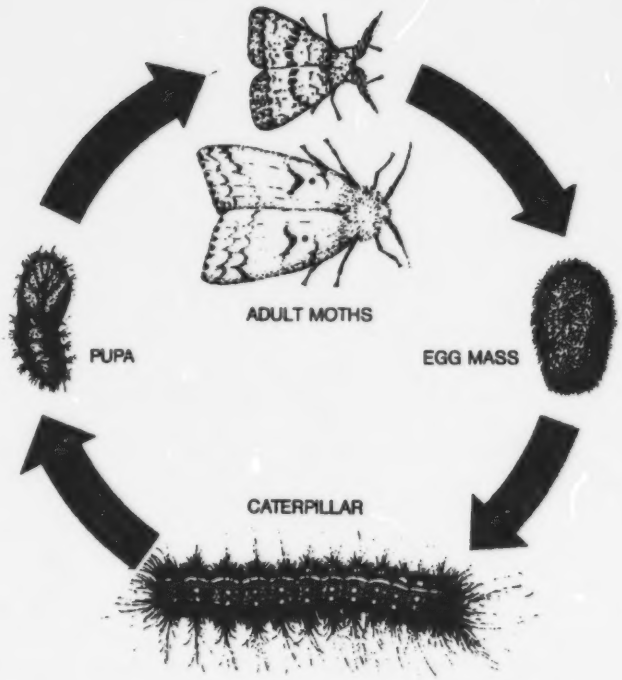
A newly-hatched larva is buff-coloured, but soon turns black. If larvae hatch during rainy or cool weather, they will remain on the egg mass until conditions improve. Otherwise, they are attracted to light and will move upward. The larva, barely 4 mm (approximately 1/4") long, is now in its first instar. As it molts, it will go through four more instars if it is a male, five more if a female. Larval activity lasts over two months and extends through May, June and into July.

As the first instar larva climbs, it spins a silken thread. It may hang on this thread and be blown away by the wind. This is called "ballooning" and is the most effective natural method of dispersal used by the gypsy moth. Although first instar caterpillars can be transported for short distances by the wind, the transportation of egg masses and other life stages on automobiles, campers, lumber and the like is a more important means of introducing the insect to new areas.

The first instar lasts 5 to 10 days. The next three or four instars take about a week each, and the fifth (males) and sixth (females) last between 10 and 15 days. The actual length of each instar depends on weather conditions.

Dramatic Changes in Fourth Instar

In its fourth instar, the larva undergoes dramatic changes in both appearance and habit. It grows to about 2 1/2 cm (1") long and the 11 pairs of tubercles (spots) on its back become visible. The first five pairs are bright blue; the remaining six pairs are red. Larvae in instars 1-3 stay on the leaves day and night. Once they reach the fourth instar, however, they move off the foliage to hide in sheltered places on the tree or the ground during the day and feed at night.



Gypsy moth life cycle.

During the larval stage, a gypsy moth caterpillar eats an average of 1 square metre of foliage, the male slightly less and the female slightly more. The last larval instar causes the most damage to trees. During this period, usually in June or early July, the caterpillar devours almost three quarters of the foliage it will eat in its life cycle. This is why the damage caused by the insect appears so suddenly. Adult moths do not feed at all.

Caterpillar Changes to Pupa

Depending on the weather and the quality of food the larva has been eating, it will enter the next stage of its life, the pupa, in mid to late July. The gypsy moth pupa is a dark, reddish-brown colour and is attached to a tree trunk, rock, or other sheltered place by a loose net of silken threads.

After remaining in the pupal stage for 9-17 days (females remain a few days longer than males), the pupa splits its shell-like skin and emerges as an adult moth. Males are a mottled brown; the much larger females are a creamy white with black markings. The female cannot fly; she attracts a mate by emitting a powerful pheromone, or sex attractant. Males are equipped with large feathery antennae and pick up the scent of this pheromone. The male flies in a zigzag pattern toward the source of the pheromone. Once he locates the female, he communicates by dancing over and around her while rapidly beating his wings and the pair mates. Shortly after mating the female deposits her eggs close to where she pupated. Both males and females die, each pair leaving behind as many as a thousand descendants.

Our Forests are Under Stress

Like any community the forest is in a state of constant change. Trees are "born", they multiply and they die. Similar to other communities, the relative health of individual trees, and hence the forest, is dependent on the number of stresses placed on them. For humans, a little stress is a good thing, or so we are told. The same can be said for trees; but when stress-causing factors become too numerous, they have a detrimental effect. Sources of stress during a tree's lifetime are abundant. There are seasonal temperature extremes, droughts, pests, airborne pollutants (including acid precipitation and ground level ozone), poor soils, overcrowding and poor tree care practices. The gypsy moth is an important member of this list.

Losing Leaves - Is It a Big Deal?

If a tree on your property loses its leaves in mid-summer to hungry gypsy moth caterpillars, you will undoubtedly wonder if the tree will survive. There are many factors involved, which make the question difficult to answer.

Six key factors play a role in determining the fate of a tree after the gypsy moth has finished feeding:

1) The amount of foliage removed;
2) The weather;
3) The number of years of repeated defoliation;
4) Timing of defoliation in the growing season;
5) The presence and number of other insects and diseases;
6) The health and vigour of the tree at the time of defoliation.

These are only the most crucial factors. The tree's habitat also affects its survival. Habitat factors include soil depth and crowding by other trees. The interaction of two or more of these factors will ultimately determine the impact of defoliation on a tree.

The Importance of Leaves

Leaves play a very important role in tree survival. Light captured by the leaves is converted into plant food through a process called photosynthesis. The starches produced are stored in the roots. Starch is required by the tree for growth. Loss of leaves reduces the rate of photosynthesis and the amount of starch in the roots begins to decrease. The starch reserves can be built back up if a second set of leaves is produced by the tree.

Trees - Coping with Stress

A reduction in the number of leaves on a tree reduces the tree's ability to produce food. When all or most of the leaves are removed, broad-leaved trees react by producing a second crop of leaves from dormant buds to replenish food reserves.

This "refoliation" usually occurs in mid to late July, after gypsy moth feeding is complete. The second set of leaves are often smaller and poorly formed compared to the first set. The ability of the second set of leaves to produce food is less than optimum but they do allow the tree to replenish some of its starch reserves in the roots. The majority of food production is done in early spring before gypsy moth defoliation occurs. However, it takes a tremendous amount of energy for the tree to rebud and releaf. This energy is being borrowed from energy supplies required for leaf-out the following spring. Sometimes broad-leaved trees do not refoliate due to the lateness of the season or drought conditions. This may be advantageous to the tree by saving energy for leaf-out the following spring.

Conifers normally have two to five years of needles on their branches. The impact on these trees is more serious because they are not able to releaf after being defoliated. Fortunately, feeding on conifers by gypsy moth is not that common.

In heavily infested areas, trees may be stripped bare by mid-summer as illustrated from the ground and the air. (Copyright 1990 by Nathan Bacon).

Short-Term Impacts

Seeing multitudes of black hairy caterpillars on your trees for the first time can be a disheartening sight. Trees stripped of their leaves detract from the aesthetic appearance of property. The frass (droppings) can stain wood and concrete and create a mess after a rainfall. A conifer (evergreen) tree that is completely defoliated may die after one year. Healthy broad-leaved (hardwood) trees will usually survive several years of defoliation provided they are not under severe stress from other factors.

In the years following defoliation, tree crowns may appear unhealthy and contain many dead branches. Small, poorly-formed leaves are also common.

Defoliated trees allow more light into the forest. This can alter wildlife habitat by affecting plant growth on the forest floor. Some wildlife may thrive while other species which are accustomed to sheltered, cool conditions may move out of defoliated areas temporarily and into areas where shade exists.

There can be positive effects of gypsy moth infestation. As outlined above, periodic defoliation allows plants on the forest floor to receive more sunlight for a number of years. The change in the light conditions will often result in a change in the types of plants growing at that location. This provides species and habitat diversity in the forest without a natural calamity such as a wildfire or a severe windstorm.

Direct sunlight increases the rate of drying in the forest. As a result, drought conditions may exist and the risk of forest fire may increase.

Long-Term Impacts

Repeated defoliation for more than three or four years may be too much for some trees to cope with. Fortunately, gypsy moth populations have not remained high for more than two or three consecutive years in most Ontario locations. Healthy, vigourous trees in a well managed forest can usually withstand several years of defoliation with few lasting effects and recover quickly from the short-term impacts. Those trees that are diseased, crowded or stressed by other factors may die after one or two years of defoliation.

The height and diameter growth of defoliated trees slows down after gypsy moth attack because less food is available to produce the new growth. In Ontario, significant tree mortality due to gypsy moth has not been observed.

In the United States, the number of oak trees has decreased in some forest stands but the oaks are being replaced over time by other tree species that are less favoured by the gypsy moth.

Oak forests in Ontario provide acorns for many species of wildlife. Acorns are an important food source for deer, allowing them to stay healthy and survive harsh winter conditions.

A Delta type pheromone trap for capturing adult male gypsy moths is one of the survey tools used to monitor gypsy moth populations.

Gypsy Moth Impact Studies

To improve gypsy moth management, forest managers must have tools to evaluate the level of susceptibility and vulnerability of forests to gypsy moth defoliation.

The Southern Ontario Forest Health Unit of the Ministry of Natural Resources has established gypsy moth study plots throughout southern Ontario. Plots have been located in a variety of forest types to enable researchers to determine the impact of this pest on tree growth and forest health. Long-term monitoring of the changes in the health and growth of trees will provide a better understanding of the relationship between the gypsy moth and different forest types.

Egg mass surveys, pheromone trapping of male moths and defoliation surveys are other useful techniques being used to monitor the dynamics of gypsy moth populations.

Gypsy Moth - Looking for a Free Ride

Gypsy moth moves from infested areas to new areas in two different ways--by moving in the wind *and* through human transport. A female gypsy moth cannot fly so she lays her eggs very close to the spot where she pupated. Much of the natural spread occurs when newly hatched caterpillars are blown from tree to tree. The tiny caterpillars spin fine threads from their bodies as they move. When they crawl into the tree tops some of them hang from this thread. The thread is easily broken and because the small caterpillars are hairy and light they "float" on air currents. The gypsy moth does not move very far this way. On flat ground, 99 per cent of the caterpillars travel no further than one kilometre. However, stow-away gypsy moths can be transported great distances with help from humans.

The name "gypsy" is quite appropriate for this insect as gypsy moths often hitch a ride to infest new areas. Female moths frequently lay egg masses on outdoor articles, equipment or vehicles. This is the principal means of dispersal of this insect over long distances. Once in a new area, populations can expand rapidly from tiny isolated infestations to the surrounding forest where there is no competition for food and enemies are not yet established.

What to Look for

All stages of the gypsy moth can be inadvertently transported to new areas--larvae, pupae, moths and eggs. Egg masses are the life stage most commonly moved from place to place.

When to Look

Larvae (caterpillars) — **May to July**

Pupae — **July**

Moths — **July to August**

Egg Masses — **July to May**

Where to Look

Female gypsy moths prefer to lay eggs in sheltered hiding places. Look for egg masses on camping equipment, lawn furniture, the undercarraige of vehicles, firewood, trailers, boats and lumber. Inspect your belongings carefully before leaving your cottage, home or campground. Examine household articles left outdoors for the summer before packing and moving them to new areas.

Gypsy moth egg masses may be easy to spot on your property or they may be well hidden in a sheltered location.

What Can A Homeowner Do?

In areas where there is no organized gypsy moth control program, people with serious infestations often feel helpless as their trees are devoured and caterpillars migrate over everything. Even with a coordinated control program, the magnitude and complexity of the task makes 100 per cent success impossible. No single control method can eliminate the insect completely, nor can several methods used together. In that light, just what can the homeowner do?

Scraping and Destroying Egg Masses

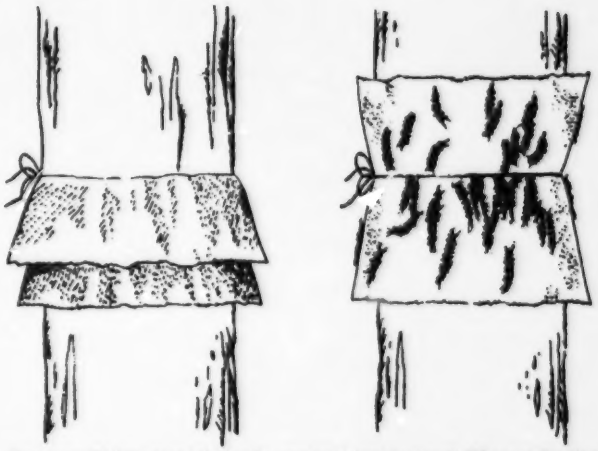
People can have an impact on gypsy moth survival long before the caterpillars hatch by searching for the buff-coloured egg masses and destroying them. Egg masses are easiest to see when leaves are off trees, so this technique is most effective from fall to early spring. Each egg mass contains from 100 to 1,000 eggs. Egg masses can be found on tree trunks, under branches, on rocks, wood piles, fences, and nearly any other surface, including buildings. The best bet is to scrape the masses into a container of soapy water (a teaspoon of detergent per litre) and soak them for one week. Alternatively, they can be burned in a fireplace. **Scraping eggs onto the ground will not prevent them from hatching**. There are many home brews used for spraying on egg masses, but their effectiveness has not been proven and they may harm trees. *Keep in mind that a pesticide must be specifically labelled for spraying on gypsy moth eggs before it can legally be used for that purpose.*

If you have a large forested property, egg scraping will be a daunting task. Many egg masses are found far above the ground, however, the egg masses that cannot be reached are the most susceptible to overwinter killing by cold temperatures (lower than -25°C). At least destroying those within reach may make the difference between complete defoliation and just an ugly nuisance. Cold winter temperatures in more northerly areas may kill many of the eggs above the snow, therefore, it is more important to concentrate search efforts close to the ground where eggs will be insulated by the snow cover.

Tree Banding

Once the eggs have hatched in early spring, it is too late to scrape egg masses. The next line of defense is tree banding. This is a popular method, but is often misunderstood. A short lesson in gypsy moth caterpillar behavior will clarify the issue.

As caterpillars grow and develop, their ability to travel increases. They tend to do most of their leaf-munching at night when the air is cool and humid. As daytime temperatures rise, many will seek shelter from sunlight and exposure to predators. Some, but not all, will move right down the trunk to hide in dead leaves or underbrush. If they happen upon a sheltered site on their way down, they will often take advantage of it. Caterpillars find a loose flap of burlap especially inviting. But here's the catch. The burlap will not kill them nor will it prevent them from going back up the tree. You must destroy them--preferably every day in the late afternoon. Crush them if you like, or sweep them into a container of soapy water.



Gypsy moth larvae seek shelter under a burlap band. When collecting larvae, wear gloves to avoid human skin irritation from larval hairs.

It is best to install a loose, double-layer skirt of burlap by folding a 40 to 60 cm (16 to 24 inch) wide strip over a piece of twine and tying it all the way around the tree. If the flap is too tight against the tree, the caterpillars will have a tough time crawling under it, and it will be difficult to lift it to remove them. Cut four slits in the burlap band to create quarter panel flaps which makes the burlap easier to lift for removing caterpillars.

Sticky Tape

The use of various sticky materials is questionable, but if you must use one, do not apply it directly to the bark. This can leave a permanent scar or even kill the tree. Wrap the tree with a protective material (duct tape on rough-barked trees; foil or paper on smooth barked trees) and apply the sticky material on top of this. Pressing tape into all cracks and crannies on rough-barked trees prevents caterpillars from crawling underneath. The barrier stops caterpillars from crawling up the tree from the ground; burlap bands intercept those crawling down the tree.

Pheromone Traps

Some garden centres and hardware stores sell pheromone "sex lure" traps that catch adult male moths. These have their uses in organized programs where gypsy moth populations are low, but are of little value when used individually.

Ground Application of Insecticides

Insecticide application from the ground is an alternative if a significant problem exists where there will be no aerial spraying. Many firms will spray small areas from the ground or homeowners can do limited amounts of spraying on small trees. Keep these points in mind to save money and avoid frustration: 1) See the caterpillars for yourself before paying to spray--do not spray if it isn't necessary; 2) Do not apply insecticides after caterpillars are gone. This sounds obvious, but there have been instances where spraying was done many weeks too late; 3) Refrain from treating not susceptible tree species like cedar and ash; 4) Plan early; and 5) To minimize environmental impacts, consider using biological controls.

Natural Controls of Gypsy Moth

The enemies of the gypsy moth are represented by the three 'P's : **Predators Parasites Pathogens**
Native forest insects such as the forest tent caterpillar are kept under control by a community of natural enemies. When the gypsy moth came to North America it left its natural enemies behind. However, two things have happened over the past 100 years--some of the gypsy moth's natural enemies are now at work here and some native enemies have adapted to it.

Once an Enemy, Always an Enemy

In the first half of this century many of the gypsy moth's natural enemies from around the world were released in the United States and Canada. Most were insects and many became established in North America. Some of these imported enemies have followed the gypsy moth into Ontario. Some native mammals, birds and insects have adapted to take advantage of the gypsy moth.

Ganging Up on the Gypsy Moth

The enemies of gypsy moth fall into three distinct categories:

PREDATORS are animals which actually eat the gypsy moth. Some examples include white-footed mice, shrews, spiders, skunks, carpenter ants, beetles and about 40 species of birds. Predators do not have a preference for any particular life stage of the gypsy moth. They feed on a variety of prey species and do not seek out the gypsy moth exclusively but will eat it when it is available and locally abundant. Predators of the gypsy moth play a role in the collapse of outbreaks.

PARASITES are usually insect species which consume and kill the gypsy moth by living inside it. There are over 100 known insect parasites of the egg, larval and pupal stages. Certain flies and small non-stinging wasps are examples of gypsy moth parasites. Unlike predators, parasites are usually very specific feeders. They commonly attack only gypsy moth at a certain stage in its development. Parasite populations build up in response to large gypsy moth populations, however, parasite control is most effective when gypsy moth populations are low.

PATHOGENS are diseases which can be found naturally in the environment. A well known pathogen, Bacillus thuringiensis (B.t.) is a bacteria which is specific to caterpillars that become moths and butterflies. B.t. occurs naturally in the soil. Commercially produced B.t. can be purchased in small quantities from a hardware store or lawn and garden centre, and sprayed on trees much like a more conventional insecticide.

Another pathogen is a naturally occuring nucleopolyhedrosis virus or NPV which is specific only to the gypsy moth. This virus causes infected larvae to appear "wilted". Unlike B.t., the NPV can be transmitted from one caterpillar to another and from generation to generation. In Canada, a product called Disparvirus is made from NPV-infected caterpillars by staff of Forestry Canada's Forest Pest Management Institute in Sault

Controlling Gypsy Moth - Naturally

Type	Description	Examples			Effectiveness	Recommendations for Use of Homeowner Use
Predators	animals which eat the gypsy moth.	Birds - chickadees - tanagers - blue jays - robins + about 36 others	Mammals - mice - shrews - raccoons - skunks	Insects - beetles - spiders - carpenter ants	help to keep low population levels in check. help collapse outbreaks.	create suitable habitat conditions for predators. maintain vegetation under trees.
Parasites	insects which live inside the gypsy moth and eventually kill it. usually specific to a particular life stage of gypsy moth.	Flies can affect larval or pupal stage.	Wasps several insects were imported, have become established and affect egg, larval or pupal stage.		help to keep low population levels in check. little impact on high gypsy moth populations.	try to maintain natural forest conditions around trees. research currently looking at ways to release insect parasites. Not a method for homeowner use.
Pathogens	diseases which occur naturally in the environment.	Disparvirus (nucleopolyhedrosis virus) specific to gypsy moth	Bacillus thuringiensis (B.t.) (bacterium) specific to caterpillars that become moths and butterflies.		B.t. occurs naturally in soil. Virus can cause heavy mortality in gypsy moth populations.	B.t. can be purchased and applied on small trees around homes. research involving Disparvirus spraying is ongoing. Disparvirus may be available for homeowner use in a few years.

Ste. Mari . At this time, Disparvirus is expensive and remains in a research phase. Disparvirus may be commercially available for homeowner use in the next few years.

The presence of pathogens when gypsy moth numbers are high is usually responsible for the eventual collapse of the gypsy moth population.

Gypsy moth is also vulnerable to some species of fungi. In most years, gypsy moth mortality due to fungus is generally insignificant as the fungi are dependent on very specific climatic and humidity conditions, which rarely occur.

A healthy community of predators, parasites and pathogens is important in areas where gypsy moth is present. Predators and parasites play an important role in preventing rapid population increases. Pathogens, on the other hand, are most effective when gypsy moth numbers are very high and help bring on the collapse of the population.

None of these natural control agents working singly or in combination will result in the complete elimination of the gypsy moth. In some years, the impact of the enemies will result in low gypsy moth populations. Ocassionally, outbreak conditions will occur and the presence of the enemies will not be enough to control expanding gypsy moth populations.

Encouraging natural predators to take up residence in your neighbourhood will help minimize the impacts of the gypsy moth.

Biological Control - What is it?

Gypsy moth has a host of natural enemies that are present in the environment. Biological control involves encouraging these natural enemies in areas where the gypsy moth is found. Attracting birds, mammals and insects which prey on gypsy moth to your property is a simple biological control method.

Benefits of Birds

About 40 species of birds have been found to feed on the gypsy moth. Vireos, chickadees, tanagers, orioles, robins, blue jays, grackles, starlings, blackbirds and cuckoos are among these. To encourage birds to live in your neighbourhood you must first provide for their basic needs: food, water and adequate shelter in a comfortable and protected environment.

Cottage lots maintained in as natural a state as possible are attractive to birds. Vegetation and forest litter under trees provide suitable habitat for birds and other gypsy moth predators. Planting a variety of native tree and shrub species, especially those which produce fruit, will create good habitat for birds. A bird bath or small pond will satisfy water requirements. You can help by building bird houses or nesting platforms and leaving nesting materials such as straw, yarn, dried grass and similar materials around your property.

How Susceptible are Your Trees?

The presence of gypsy moth in an area is influenced by the trees growing there. Although gypsy moth feeds on a wide variety of host plants, oak trees are preferred and are essential for development of young larvae. The susceptibility of a property to gypsy moth can be influenced by the trees planted or removed. Trees that are planted should be suitable to the site and local climate. Trees such as ash, red spruce or cedar are less susceptible to defoliation by the gypsy moth. A diversity of tree species and ages will discourage gypsy moth.

The Gypsy Moth's Diet

Although the gypsy moth seems to eat anything that is green, especially in areas of high population densities, it does have definite preferences. These have been classified by foresters into categories:

Most Preferred	Intermediate	Least Preferred
oak (all species)	beech	black ash
largetooth aspen	yellow birch	green ash
trembling aspen	cherry (all species)	white ash
white birch	butternut	black locust
grey birch	chestnut	mountain maple
basswood	white elm	red spruce
tamarack	eastern hemlock	white cedar
alder	ironwood	eastern red cedar
apple	maple (most)	sumac
hawthorn	white spruce	red mulberry
willow	Norway spruce	tulip-tree
Manitoba maple	pine (all species)	balsam fir
mountain ash	hickory	sycamore
Carolina poplar	black walnut	
larch	sassafras	
	serviceberry	

Give Your Trees Some Help

Healthy, vigourous trees with adequate moisture, soil and space are able to withstand the hardship of defoliation better than trees under stress. Water trees during dry summer periods, especially in areas where soil is coarse and shallow. Placing mulch around the base of trees will help prevent loss of soil moisture in the summer. Disturbance of soil and fine roots can interfere with the tree's uptake of water and nutrients. Tree roots near driveways or heavily travelled areas may be adversely affected by soil compaction. Fertilizing may do more harm than good for trees already under stress from drought, insect attack or other factors. Trim trees to reduce the size of the crown and prune dead branches. A forester or a tree maintenance professional can provide more information on proper tree care.

Pesticide Safety

Pesticides are normally composed of several ingredients. The active ingredient, the part that actually kills the pest, must be stated on the label so that the consumer is aware of what is being purchased.

Are Insecticides Dangerous?

Insecticides are safe if used properly. Insecticides, along with many other chemicals have the potential to kill humans or animals if misused. The relative toxicity of any pesticide can be measured to ensure safe use.

One measure of toxicity, acute toxicity, is expressed as the amount of active ingredient required to kill 50 per cent of a population of test animals. This is the lethal dose or LD_{50} and is expressed in milligrams of active ingredient administered per kilogram of body weight of the test animal. The smaller the number, the more toxic the material, since less material is needed before lethal effects are noted. The following table lists the LD_{50} for some common materials:

Acute Oral Toxicity

Material	LD 50 (mg/kg)
B.t.	+15,000
ethyl alcohol	13,700
ethylene glycol (antifreeze)	3,500
table salt	3,300
aspirin	1,750
acephate	900
carbaryl (Sevin)	**540**
fenitrothion	450
aminocarb	30
amphetamine	5

Increasing Toxicity

Chronic or long-term toxicity is also important. A large number of "long-term" studies are carried out to assess the potential for chronic toxicity. Many of the tests are carried out over 1 or 2 years or several generations of the test animals. High doses of material are intentionally used. If no detrimental effects are found over the long term using deliberately high dosages, then it is highly unlikely that recommended dosages used occasionally will be deleterious to human or animal health.

What are the effects of insecticides on environmental quality?

There is no general answer to this question because each insecticide has specific properties and interacts with the environment differently. All of the insecticides used for gypsy moth control must be registered in Canada and approved for use in Ontario. The registration process is long and rigorous involving a multi-agency review including the Canadian Wildlife Service, the Environmental Protection Service, Health and Welfare Canada, Fisheries and Oceans, Agriculture Canada and Forestry Canada.

Each agency must review extensive data gathered under trial conditions and determine if the product can be registered in Canada. Only then is it available for sale and use in this country. This registration process is generally regarded as the most stringent and safest in the world.

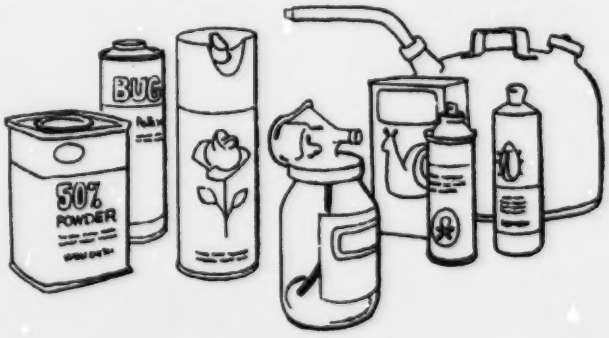
Use of Insecticides

Insecticides should only be used when absolutely necessary (i.e. where tree health is threatened). Use the least toxic material that will be effective, to help protect environmental quality and, wherever possible, use biological controls.

Insecticides, both biological and chemical, when used properly by the homeowner, are safe and effective controls for caterpillars on small, individual, easy-to-reach trees. Closely examine the label of the product you have chosen to ensure that "gypsy moth caterpillars" are listed as target insects. No matter which insecticide you choose, be sure to **READ THE LABEL** and **FOLLOW THE DIRECTIONS CAREFULLY.**

Homeowners carrying out a spray program on their own property must use federally registered and provincially approved insecticides. Protective equipment must be worn (rubber gloves, safety glasses, clothing which covers all parts of the body) when applying pesticides if this is specified on the label.

Information on pesticides may be obtained by dialing the Agriculture Canada National Pesticides Information Service at 1-800-267-6315 between 10:00 a.m. and 3:00 p.m. Monday through Friday.



Biological or Chemical?

What makes beer or ice cream "light"? How is coffee decaffeinated "naturally"? And what on earth does "wholesome" mean on a package of cream-filled snack cakes?

The english language bulges with terminology that has become vague or even totally meaningless through misuse. The area of pesticides is a perfect example. Just what makes one "biological" and another "chemical"? In the end, all pesticides are made up of chemicals. Differences lie in how they are produced and how they act upon pests.

A "biological" pesticide is, or once was, a living substance, or is produced by a biological means such as by plants or microbial organisms. "Chemical" is often used to refer to any material that is produced by a non-biological process from non-living substances.

As it happens, the most common biological pesticides such as Bacillus thuringiensis (B.t.) tend to be highly specific towards insects and quite safe to humans and the environment.

On the other hand, "chemical" pesticides include many highly dangerous compounds, but also others that are quite specific to insects and of very low human or environmental hazard.

The two materials used by virtually all private sector gypsy moth control programs in Ontario are B.t., a "biological" insecticide and carbaryl, a "chemical" insecticide. B.t. is the only insecticide used for aerial application in Ministry of Natural Resources pest management programs in Ontario. Both insecticides have advantages and disadvantages and both rank quite low in human or environmental hazards when compared with other pesticides.

Bacillus thuringiensis *subsp.* kurstaki (B.t.)

B.t. (Bacillus thuringiensis), is a product made from naturally-occurring bacteria. It is approved for home and garden use. It kills leaf-eating caterpillars by damaging their digestive systems. The insecticide containing the B.t. must be sprayed onto leaves where the caterpillars are feeding. The caterpillars must eat enough of the treated leaves to make them sick. The caterpillars stop feeding soon after eating the treated foliage but may not die for one to five days. B.t. is generally applied in the last half of May and the first half of June when caterpillars are still small. Two applications of B.t., separated by a few days to a week, usually will provide increased control in areas where there are high populations of gypsy moth. Two applications are necessary because egg hatch in Ontario is often extended over a long period of time in the spring.

What is B.t.?

- The active ingredient in this insecticide is a bacterium which occurs naturally in the soil. Hence, the use of B.t. represents a natural or biological control of insects.

- The B.t. bacterium produces spores and crystals. The spores allow the bacterium to reproduce. The crystals contain a protoxin which is activated to a toxin when eaten by caterpillars.

- B.t. *subsp.* kurstaki only affects caterpillars which become moths and butterflies (lepidopterous insects). Other insects such as beetles, flies, spiders and lepidopterous insects in non-caterpillar stages are unaffected.

- Products with B.t. as their active ingredient contain both spores and crystals. Products for home use include: **CIL Organic Insect Killer Liquid**, **Thuricide R-HPC for Home Gardens** and **Dipel WP** and may be found at hardware stores or garden centres. Check the product label to ensure that Bacillus thuringiensis or B.t. is listed as the active ingredient.

How does B.t. work?

- The spores and crystals sprayed on tree foliage must be eaten by caterpillars to be activated. Feeding will continue for a short period of time.

- The crystals release a toxic protein when they are dissolved in the alkaline digestive system of the insect. (Human digestive systems are acidic.)

- Gut paralysis occurs and feeding ceases.

- The ingested spores invade the circulatory fluid, germinate and multiply. The insect dies in one to five days.

Are there environmental effects?

- B.t. is not harmful to mammals, birds or fish. B.t. biodegrades in three to seven days.

- The oral LD_{50} (a measure of toxicity) for rats is greater than 15,000 mg/kg. In comparison, table salt has an LD_{50} of 3,300 mg/kg (higher numbers represent lower toxicity).

- B.t. has no toxicity to predators or parasites of the gypsy moth.

Are there health effects?

- B.t. is safe for use in forested residential areas.

- No emergency measures are required in the event of exposure to the spray. Wash sprayed items with soap and water.

● If a vegetable garden or wild berries have been sprayed, wash items before eating.

What variables are involved in the use of B.t.?

● B.t. is relatively slow acting and timing of applications must be precisely linked to the degree of leaf development, the stage of development of the caterpillar and weather conditions.

● Gypsy moth larvae from different geographic areas may differ significantly in their susceptibility to B.t.

● Even coverage of foliage gives the best results.

● Since B.t. is a biological agent, strict storage and use conditions must be followed to ensure high effectiveness.

● Two applications of B.t. may be necessary to protect foliage where large numbers of gypsy moth exist.

● B.t. is mixed with water or mineral oil. On a sprayed block of land, rainfall six hours before or six hours after the time of spraying may reduce the effectiveness of the insecticide.

CARBARYL

Carbaryl, the active ingredient in commercial insecticides like "Sevin", is an effective chemical insecticide and is registered for domestic use. **Carbaryl is toxic to many insects directly exposed to spray residues, including bees and beneficial predators and parasites of the gypsy moth.** Carbaryl must not be sprayed over water. Normally a single application of carbaryl is sufficient to protect tree foliage.

What is Carbaryl?

● Carbaryl is a synthetic organic carbamate insecticide.

● Carbaryl is the active ingredient in products such as **Sevin WP** and **Sevin XLR**.

● Carbaryl is a broad spectrum insecticide, effective in controlling a wide range of insects. It acts both as a contact poison externally and as a stomach poison by disrupting normal nerve function.

Uses of Carbaryl

● In Ontario, carbaryl is used on alfalfa, cereals, tobacco, strawberries, apples, grapes, tomatoes, carrots, forest and ornamental trees and in pet flea collars.

● Carbaryl is federally registered and provincially approved for ground and aerial application in the control of the gypsy moth in forested areas.

Are there health effects?

● The oral LD_{50} (a measure of toxicity) for rats is 540 mg/kg. In comparison, Gravol has an LD_{50} of 500 mg/kg. The LD_{50} of B.t. is +15,000 mg/kg (high numbers represent lower toxicity).

● If carbaryl comes into contact with the skin, wash off immediately. Because carbaryl can easily be washed off of the skin, absorption through the skin is not a concern. Wash sprayed items with soap and water.

Are there environmental effects?

● There is no evidence of bio-accumulation of carbaryl in plants or animals.

● Carbaryl is toxic to bees. This effect may be minimized if spraying is done during periods when bees are less active (i.e. at dawn and dusk).

● The most recent formulation of carbaryl, called **Sevin XLR**, has been found to be considerably less toxic to bees than previous formulations. Nevertheless, care should be taken when using this insecticide near apiaries (bee hives).

● No direct adverse effects on fish, birds or wildlife have been found in aerially sprayed regions.

● Carbaryl at high doses can be toxic to a wide range of aquatic insects. Therefore, it is imperative to follow label directions and use care near water.

● The half life of carbaryl in soil is 7 to 10 days with no residues being detectable 60 days after application.

● Carbaryl is degraded and used by soil micro-organisms.

It has been suggested that spraying, especially with chemical insecticides, will kill many caterpillars almost immediately. However, the remaining individuals will then be subjected to less competition and will therefore have a better chance of surviving. In addition, the next egg laying will be more successful and, after a short delay, the infestation will reappear. In contrast, the use of biological control agents (parasites, predators and pathogens, including B.t.) can lessen the danger of a fresh outbreak because it does not reduce the competition among individuals that occurs during the early stages of infestation. When agents such as bacteria, viruses, [illegible] other natural agents are used, the infected caterpillars which die slowly, remain within the active population and thus continue to compete for space with the healthy insects. The survivors suffer the effects of this competition throughout their lives and produce fewer and often less hardy offspring.

The objective of spraying is to keep trees green and [illegible] reducing insect populations. There is no attempt to [illegible] the gypsy moth. Some insects will be [illegible] spraying, but usually not in sufficient numbers to [illegible] defoliation. No single control method or even all the [illegible] combined can prevent the buildup and decline cycles of gypsy moth populations from occuring.

Organizing Aerial Spraying For Gypsy Moth

If your group is considering protecting the health of your trees from the effects of defoliation by gypsy moth, aerial spraying is one option to consider. On large blocks of forested land, aerial application of an insecticide may be the only economical and effective means of protection.

In Ontario, aerial spraying is regulated. The aerial spray company you hire to treat your property must be licensed and insured, and operate in accordance with the Pesticides Act and Regulations administered by the Ontario Ministry of the Environment (O.M.O.E.). All insecticides used in Ontario must be federally registered by Agriculture Canada and provincially scheduled by the O.M.O.E. Only insecticides registered for aerial application can be used. Registered insecticides have undergone thorough and rigorous testing.

How to Contact an Aerial Applicator

There are many aerial spray companies in Canada. A list of companies who provide this service in Ontario is available from your local Ministry of Natural Resources district or area office.

How Much will it Cost?

The cost of spraying depends on factors such as: the type of insecticide used, the application rate, the size of property treated, the distance from an airfield, the proximity to other spray areas, and the applicator's fee. In Ontario in 1991, landowners should be able to obtain spraying at a cost ranging from $62 to $185 per hectare per application to control gypsy moth ($25 to $75 per acre). Two applications are normally required to protect foliage in heavily infested areas. If your group is well prepared and approaches several applicators, you should receive a range of current prices.

When will Aerial Spraying Occur?

The spraying should be conducted when young caterpillars are feeding and therefore exposed to the insecticide, and before they have caused serious damage to the foliage. Spraying is not effective on older caterpillars, eggs, pupae or moths. A responsible applicator will consult with insect experts to determine the best time to spray.

Achieving good results from spraying depends on weather conditions. There should be sufficient time before or after precipitation, light winds, temperature below 16 ° C and high relative humidity. Good spray conditions typically occur just after dawn and sometimes just before dusk. Ask the contractor to provide further details about his or her precise operating conditions.

Aerial applicators may use fixed-wing (above) or rotary-wing (below) aircraft to apply insecticides on large blocks of forested land.

(Copyright 1990 by Nathan Bacon).

What will happen during Spraying?

The spray aircraft will fly in successive swaths, about 15 metres (50 feet) above the trees at a speed of approximately 160 km/hr (100 mph). You will not see large amounts of liquid trailing from the aircraft. The total spray mixture is rarely more than 3 litres per hectare (1/4 gallon per acre). The spray is deposited as a fine mist.

How to obtain the Services of an Aerial Sprayer

The following steps briefly outline procedures:

1. Decide that you want to protect foliage on your property from gypsy moth defoliation.

2. Determine the area you want treated. On a 1:50,000 scale topographic (contour) map or an aerial photograph, mark the exact area that you want to have sprayed. When you choose boundaries, use landmarks that are visible from the air, such as edges of fields or rocky outcrops.

3. Carefully calculate the area of forested property you want treated - called the spray block(s).

4. Speak to other people in your area who may also be interested in protecting their woodlots. If you all work together you can reduce your costs.

5. Make a list of landowners in your locale who are interested in spraying. The list should include the location of each property by municipality, township, lot, concession, and the area of each spray block.

6. Appoint one or two spokespeople for the group. At this point the spokespeople take over.

7. Prepare a tender to be forwarded to aerial applicators introducing your group. The tender should contain the following:

a - The insect you wish controlled (gypsy moth).
b - The time you prefer the property to be treated (i.e. when you are present or absent).
c - The specific insecticide desired.
d - The applicator should provide **you** with an insecticide product label and a Materials Safety Data Sheet (M.S.D.S.) for that product.
e - A copy of the map(s) and/or photo(s) of the property to be treated.
f - A request for a price quotation. This could be per acre, per hectare or a total price to treat all the properties on the list.
g - A request for a quotation for any additional area(s).
h - The deadline for receipt of written quotations.
i - A request for applicator information and references.
j - A statement that the applicator will be liable for all damages incurred as a result of the operation i.e. "hold harmless the landowner".
k - Indicate who is responsible for "posting the spray block" (see **14.** below).

8. Send the tender with details to several companies. Prices can vary considerably.

9. Consider all quotations; the lowest is not necessarily the best. Check references before you select an applicator.

10. Discuss terms, timing of payments, and performance guarantees with prospective applicators.

11. Consult your group and select an applicator(s).

12. Notify the successful applicator.

13. Notify neighbors of your intentions to spray. A timely explanation of methods and purpose may avoid confrontation. (You **do not** require your neighbor's permission). However, if problems are encountered, bring them to the attention of the aerial applicator (see **7.j** above).

14. The applicator is responsibile for posting the spray block at the time of spraying. This is an Ontario Ministry of the Environment regulation. O.M.O.E. can provide details of specific requirements.

How will You know if Your Property has been Treated?

Firstly, from your contact with the aerial applicator, you should know what to expect. Walk your property prior to treatment and observe healthy insects. Gypsy moth caterpillars will be small and dark coloured in May and June. Secondly, request that the applicator advise your spokespeople when the actual spraying has been completed in each spray block. Inspect your property again after treatment as the applicator directs.

Remember that the objective of spraying is to keep trees green and healthy by reducing insect populations. There is no attempt being made to eradicate the gypsy moth. Some caterpillars will be present after spraying, but usually not in sufficient numbers to cause serious defoliation.

It is strongly recommended that landowners who wish to spray in the spring begin planning by the end of December or early January. Ideally, you should be approaching applicators by February.

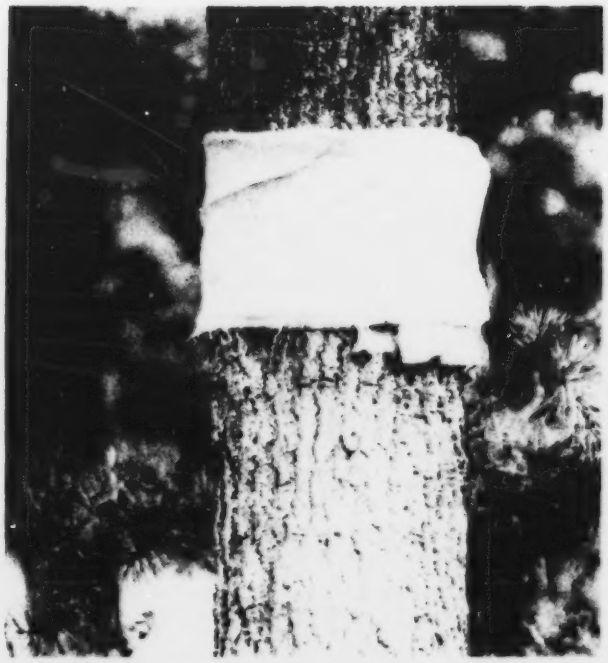
The Future of Gypsy Moth in Ontario

Gypsy moth management in the future will focus on criteria and strategies for short-term suppression of severe infestations and on long-term management of a resident insect which is capable of causing damage.

Unlike other forest insects such as forest tent caterpillar, gypsy moth has not been in Canada long enough to determine whether or not outbreaks of this pest will be a once-only phenomenon, periodic or cyclic. This makes planning a control program difficult because it is not known how long outbreaks will last and how frequently outbreaks will re-occur. The aim of an Integrated Pest Management (IPM) program is the protection of forest health. Therefore, year-to-year population behavior is an important factor in determining what action should be taken to protect high value areas.

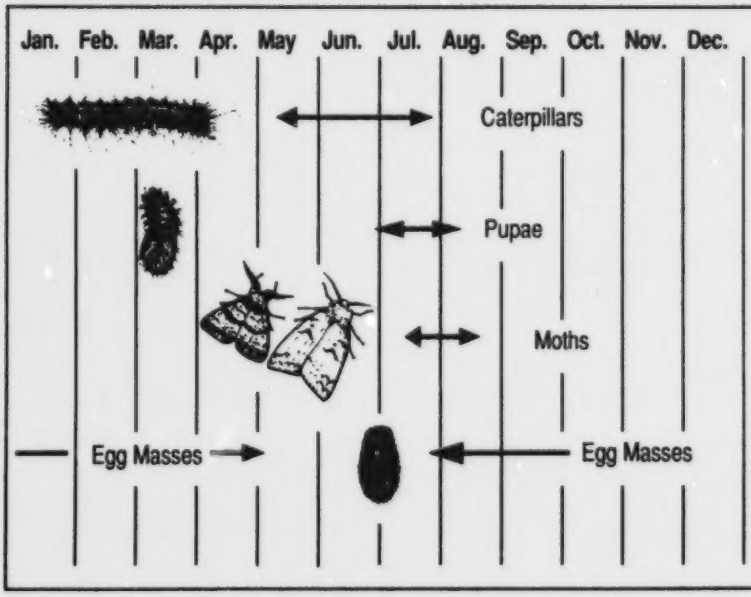
The history of the gypsy moth in the United States indicates that outbreaks are recurring events although not necessarily at regular intervals. Ontarians can probably expect to see periodic outbreaks of a few years in oak forests followed by a longer period where low, non-damaging populations of gypsy moth are present. In fact, it may be difficult to find a gypsy moth caterpillar between outbreaks.

A key component to successful integrated gypsy moth management is a high level of public involvement in monitoring populations and participating in an IPM program on their own properties.



Gypsy moth is here to stay. Getting involved in a control program on your own property may help to protect the health of your trees. Banding trees with burlap is one possible control method --see page 8 for details.

Timing of Control Measures



Recommended Treatment
Collect and destroy, use burlap traps, spray B.t., Encourage predators, plant tree species not favoured by gypsy moth.
Crush, collect and destroy, burn safely.
Collect and destroy, use pheromone traps to capture male moths (when populations are very low).
Locate egg masses on trees, vehicles, and outdoor equipment. Scrape and collect egg masses and burn them, or soak in soapy water (a teaspoon of dish detergent per litre).

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